International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:268
Vol.3, No.2, February 2014 DOI:10.15693/ijaist/2014.v3i2.93-98

Design of Electro-Pneumatic Robot using PLC and MATLAB with Smart Conveyor Management

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***Abstract*— The handling of abstract materials and mechanisms to pick and place objects are widely found in factory automation and industrial manufacturing. Over the industrial revolution this material handling technique has been highly developed right from the use of manual labor till the use of high end advance robots. In case of material handling color and shape are the most common features to distinguish between objects for sorting, recognizing and tracking.**

Generally a robot is mounted with a camera or the camera is mounted in the workspace to take the image of object then the color and shape of object are identified with the help of image processing tool of MATLAB. This technology can be used in material handling in logistics and packaging industry where the objects moving through a conveyor belt can be separated using a color and shape detecting robot.

In this paper we have introduced a robot which is controlled using PLC and object sorting is carried out through image processing toolbox of MATLAB. The robot consists of pneumatic actuators and electric gripper which is being controlled through PLC. MATLAB based image processing and IR sensors helps to recognize an object and detect their location on the conveyor line.

Index terms –PLC, MATLAB, IR Sensor, Interfacing and Execution, OEM, Pneumatic Cylinder, Solenoid Valves, Ladder Logic.

I. INTRODUCTION

Automation has not only led to improve productivity but has also helped minimize variations in manufactured components, thereby raising quality standards. Flexible and agile manufacturing concepts by integrating imaging and motion using industrial robots provide an excellent teaching tool to the field of "Mechatronics" which integrates mechanism design and analysis, soft computing, sensing and electronics.

An automated manufacturing system usually consists of a collection of material processing and handling devices. Developments in order to improve agility and flexibility in automated manufacturing systems provide advantage in the areas of cost, product architecture and product development using a component-based technology robot workcell that can be rapidly configured to perform a specific manufacturing task.

Robot is a machine to execute different task repeatedly with high precision. Thereby many functions like collecting information and studies about the hazardous sites which is too risky to send human inside. Robots are used to reduce the human interference nearly 50 percent. Robots are used in different types like fire fighting robot, metal detecting robot, etc. The first robotic arm to be used in an automobile industry was"UNIMATE" in GM motors USA in 1950s. From then there has been tremendous improvement in the research and development in robotics.

Now robots are an integral part of almost all industries. Robots have to do different tasks including welding, trimming, picking and placing etc. These robots are controlled in different ways like keypads, voice control, etc.[16]

In this system, we introduce a PLC based control of robotic arm and its movements. The image processing algorithm is proposed to detect the object and sort them using PLC interface

II. Design of system

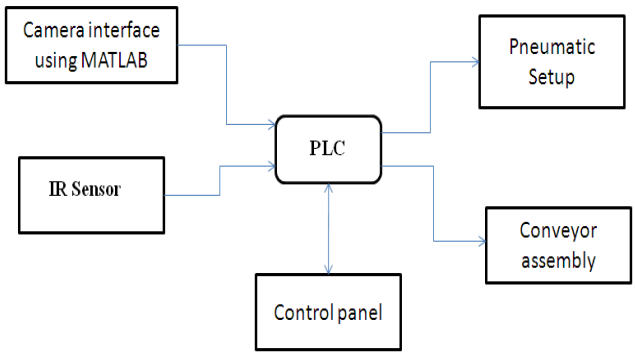


Figure 1. Block Diagram of Proposed System.

Block diagram of the proposed system is as shown in fig 1. It consist of

1. Pneumatic Setup.
2. Camera interface using MATLAB.

3. PLC.
4. Proximity Sensor.
5. Control Panel.
6. Conveyor Assembly

The proposed system is an integration of Electro-Pneumatic system, PLC and MATLAB based image processing tool. PLC is the main controller which will accept the inputs from IR sensor and interface of Image processing through MATLAB. Accordingly the PLC will control the conveyor and pneumatic robot. In addition the system is controlled via Control panel. The system can be controlled in auto mode as well as in manual mode.

A. Pneumatic Setup:

It consists of pneumatic actuators link together with the help of an mechanical frame controlled through PLC via Solenoid valves. The pressurized air is supplied through air compressor which is further regulated and filtered using Air Filter and Regulator (AFR) unit.

B. Camera interface for image processing:

The camera is used to take a snapshot of object and load the image through MATLAB using image processing.

C. Programmable Logic Controller(PLC):

The main element of the system which is used to control the Electro-Pneumatic Robot, Conveyor, and Pneumatic pushers. It accepts the inputs from interface of Image processing and IR Sensors, and accordingly gives control output signals to Electro-Pneumatic Robot, Conveyor and Pneumatic pushers, in a proper synchronized and sequential manner.

D. IR Sensor:

It is used to locate the object and give the signals to PLC for taking the necessary control action.

E. Control Panel:

It is used for manually controlling the whole proposed system in cases where PLC crashes, Emergency system shutoff, Process start and stop.

F. Conveyor Arrangement:

It is used for carrying the object from one location to another desired location. Transportation and sorting of materials is carried out on the whole conveyor line.

III. Components of Pneumatic System

The following are the components required to build the pneumatic robot. Pneumatic circuit dig. of arrangement of all components to form a robot is as shown in fig 2

a. Air compressor.
b. Air Filter and Regulator unit with indicator gauge.
c. Direction Control Valve.
d. Pneumatic Actuators.
e. Pneumatic Connectors.
f. Pneumatic Piping.

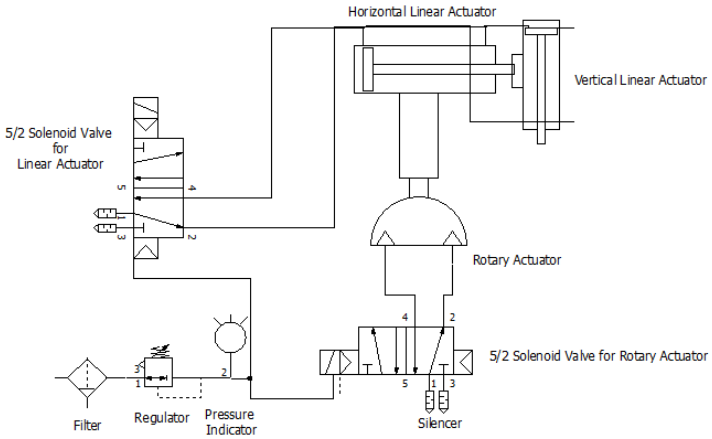


Fig. 2: Pneumatic Circuit of the system

A. Selection Parameters for Pneumatic Actuators

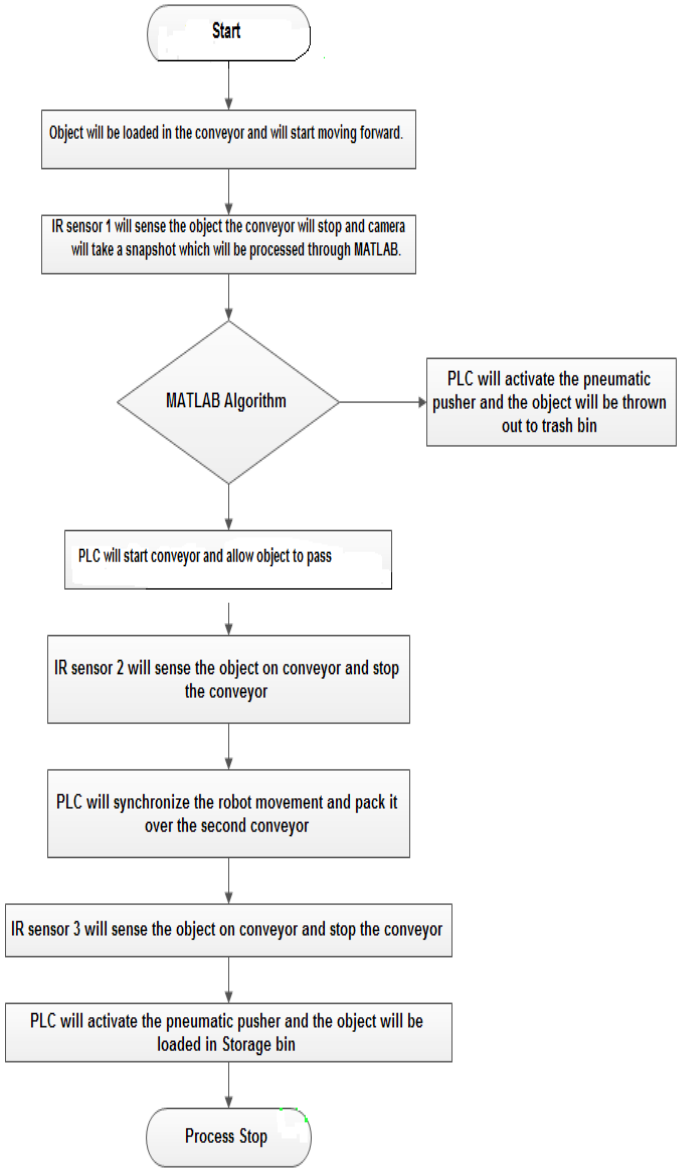
The parameters to be considered during the selection an Pneumatic Actuator are as follow:

1. ***Desired Position Timing:*** It is desired to be in the range of 1 sec to 3 sec.
2. ***Stroke Length:*** It is the length of the shaft which actuates as pressure is applied.
3. ***Alignment Angle:*** It is the angular position of the Pneumatic Actuator.
4. ***Direction of Movement:*** It is the direction in which the actuation occurs.
    a. Extended.
    b. Retracted.
5. ***Air Supply Pressure:*** According to International Slandered the intrinsically safe range for operation of an pneumatic cylinder in general purpose application is 3 Bar to 15 Bar.
6. ***Tubing Length:*** The length of the tube is an important factor as pneumatic losses may increase as tubing length increases. The following are the locations where pneumatic piping length is considered.
    a. Air Supply to Valve.
    b. Valve to Pneumatic Actuator.
7. ***Load Setting*****:** Various kinds of loads on the pneumatic actuators are considered. These are as follows:

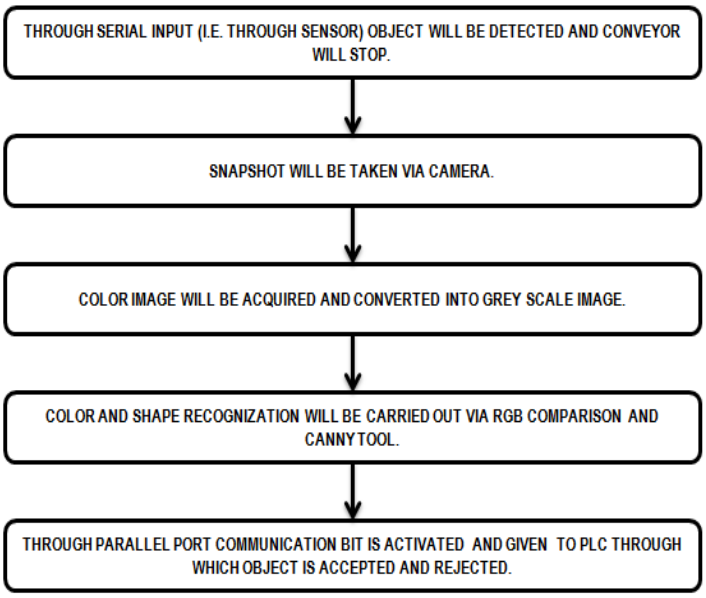
a. Moving Mass.
b. Additional Thrust.
c. Additional Friction.

IV. DESIGN OF PROPOSED ALGORITHM

A. *Design aspects of Ladder Logic*



B. *Algorithm for Image Processing using MATLAB:*



C. *Input-Output Configuration for PLC*

i. Input Configuration

a) Computer output - 1 input.
b) IR Sensor - 3 inputs.
c) Start, Stop and Emergency stop switch - 3 inputs.
d) Joystick - 4 inputs

ii. Output Configuration

a) Pneumatic Cylinder - 4 Outputs.
b) Electronic Gripper - 1 output.
c) Rotary Actuator - 1 output.
d) Conveyor Motor - 2 outputs.
e) Indicators - 3 outputs

iii. Total 11 Inputs and 11 Outputs are required for the given system.

V. INTERFACING BETWEEN PLC AND PC(MATLAB IMAGE PROCESSING)

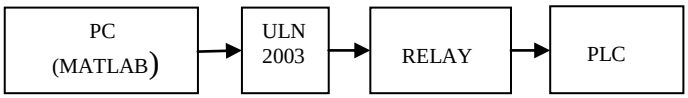


Figure 3 Block diagram of interfacing circuit

1. Personal Computer: - It has DB25 parallel port that has output 5V voltage & 100mA current.
2. ULN2003: - This IC boosts the current from 100mA to 500mA.

3. Relay:- This is DPDT Relay used to connect PLC & convert 5V voltage signal to 12V.
4. Programmable Logic Controller (PLC): - It is used to acquire the signal and accordingly synchronize the Electro-pneumatic robot.

VI. APPLICATIONS

1. Use of Ladder logic programming instead of OEM software will suite the maintenance and training needs.
2. Optical Sorting of metals and minerals.
3. Packaging and logistic application
4. Production lines.
5. Material Handling and transportation.
6. Luggage sorting at ship yards and airports.
7. Fault detection in assembly lines.

VII. Results

The design of Electro-Pneumatic Robot using PLC and MATLAB with Smart Conveyor Management has been developed and testing has been done. The objective is met by sorting the objects based on the colour feature from a group of objects.

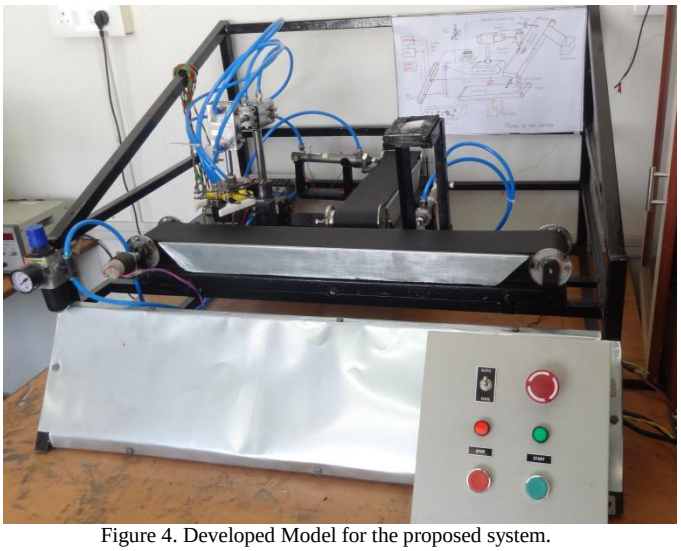


Figure 4. Developed Model for the proposed system.

An algorithm in MATLAB is programmed in order to display the image of the incoming object using a GUI platform in MATLAB. As the object reaches the desired location the conveyor is stopped, the Camera acquires the image, processes it using designed algorithm in MATLAB. If the object satisfies the objectives of shape and color using communication port the signal is fed to PLC which controls and synchronises the robot to picks the object and places in the desired location. The robot gets the signal about the position of the object in the workspace through the IR sensor. The desired operation is met and the robot gets back to the home position in order to fetch the other object, once the current operation is performed.

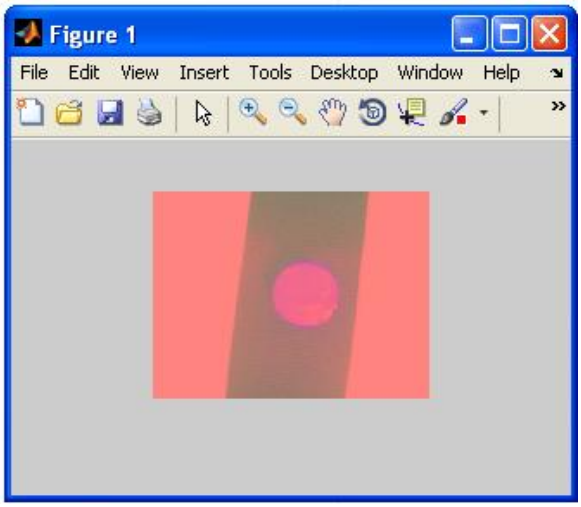


Figure 5. Accepted object

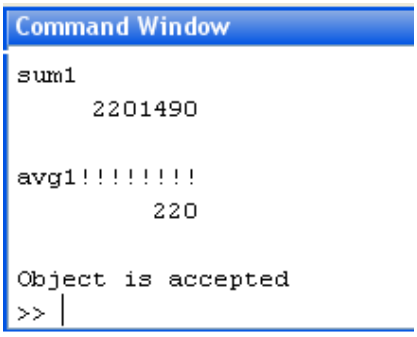


Figure 6. Accepted object command window

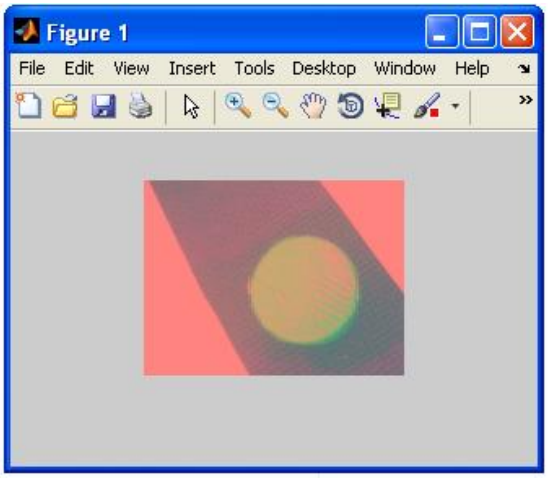


Figure 7. Rejected object

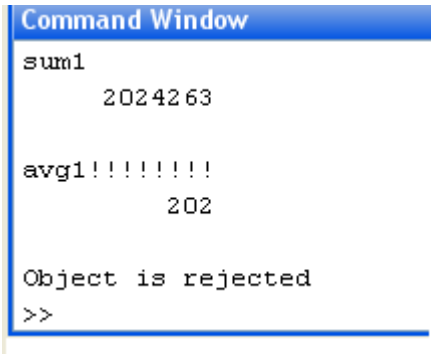


Figure 8. Rejected object command window

VI. Conclusion and Future scope

The developed robot is able to detect the color and shape of the object and place it in the desired location. Use of PLC control instead of Original Equipment Manufactured (OEM) software helps to overcome the training and maintenance duration and cost. Use of Image processing and IR sensors with reduce human involvement on conveyor lines. The color detection capability can be increased to blue and green along with red which can sort out wide range of objects by the use of flexible programming in MATLAB.

There is a wired communication between the robot and the PLC this can be improved by creating a wireless communication. The robot can be controlled wirelessly in industries with hazardous environment. Color detection along with pattern recognition and Speech recognition will play a vital role in many industries and also will increase the accuracy of the task in logistic and packaging industry. Along with this use of PC based control can help to precisely control the motion of robot and also reduce the cost of controller.

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